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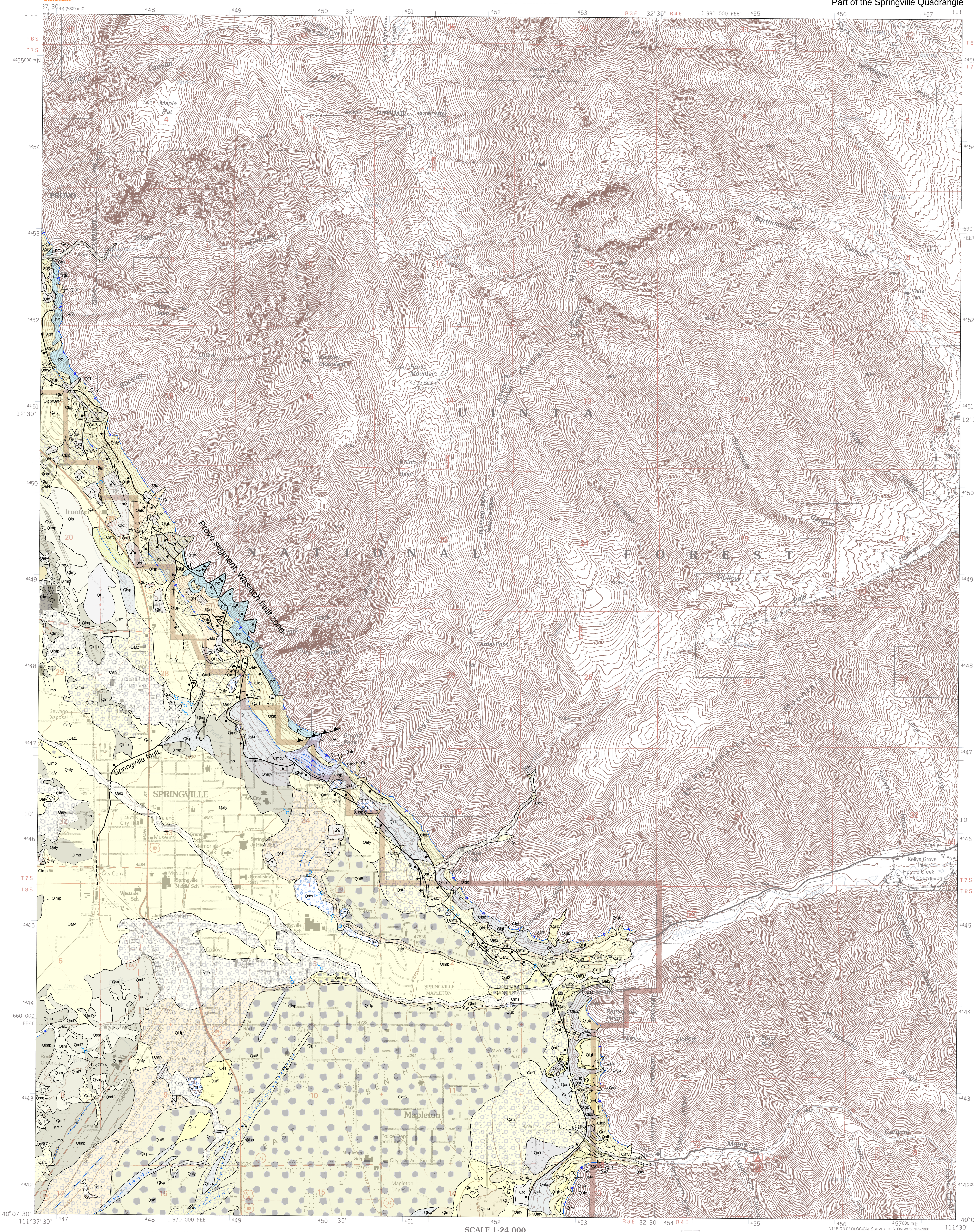
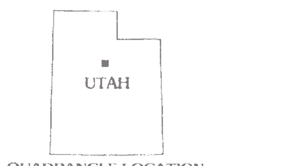


SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
SUPPLEMENTARY CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO CONVERT FROM FEET TO METERS, MULTIPLY BY 0.3048



QUADRANGLE LOCATION

1	2	3	1 Orem 2 Bridal Veil Falls 3 Wallsburg Ridge
4		5	4 Provo 5 Granger Mountain
6	7	8	6 Spanish Fork 7 Spanish Fork Peak 8 Billies Mountain

ADJOINING 7.5' QUADRANGLES

Base map from U.S.Geological Survey
Springville quadrangle, 1998
Geologic data and basemap in NAD 1927
Aerial Photo and Field Mapping:
Barry J. Solomon 2006-2007
and Michael N. Machette 1992
Bedrock Geology modified from Baker (1973)
Digital Cartography: Paul Kuehne

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Interim Geologic Map of the Southwest (Utah Valley) Part of the Springville Quadrangle, Utah County, Utah
2008

by

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INTERIM GEOLOGIC MAP OF THE SOUTHWEST (UTAH VALLEY) PART OF THE SPRINGVILLE QUADRANGLE, UTAH COUNTY, UTAH

by

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UTAH GEOLOGICAL SURVEY
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INTRODUCTION

Location and Geographic Setting

The mapped part of the Springville quadrangle covers part of eastern Utah Valley and includes the cities of Mapleton and Springville (figure 1). Hobble Creek, Spring Creek, and Dry Creek, the primary streams in the quadrangle, flow westward from the Wasatch Range to the Provo Bay portion of Utah Lake. U.S. Highway 89 extends from north to south through the map area.

Geologic Summary

Bedrock Stratigraphy and Geologic Structure

The bedrock of the Springville quadrangle consists of structurally complex sedimentary rocks of Precambrian to Permian age (shown on maps by Baker, 1973; Hintze, 1978; Constenius and others, 2006). These sedimentary strata are exposed in the Wasatch Range in the north and east parts of the quadrangle. Strata in the region were deformed by Late Cretaceous to early Tertiary contractional folding and faulting of the Sevier orogeny (see, for example, DeCelles, 2006), early to middle Tertiary regional extensional collapse or relaxation (Constenius and others, 2003), and late Tertiary to recent basin-and-range extensional faulting (see, for example, Zoback and others, 1981). The most prominent feature of the extensional faulting in the map area is the Provo segment of the Wasatch fault zone (Machette and others, 1992), which separates Utah Valley from the Wasatch Range. The Provo segment includes the Springville fault, a splay that extends about 2.5 miles (4 km) into the southern part of Utah Valley near Springville, forming scarps as much as 6 feet (2 m) high on the alluvial fan of Hobble Creek (Machette, 1992).

Quaternary Geology

The oldest Quaternary deposits in the Springville quadrangle are middle to upper Pleistocene deposits of coalesced alluvial fans that underlie piedmont slopes on the margins of Utah Valley. Exposed fan remnants in the quadrangle were deposited during the interlacustral episode between the last two lake cycles in the Bonneville Basin, the Bonneville and Little Valley lake cycles (Machette, 1992). The Little Valley lake cycle ended as late as about 130,000 years ago, and its highest level is below the altitude of the subsequent Lake Bonneville highstand (Scott and others, 1983). Remnants of the fans are exposed above and slightly below the highest Lake Bonneville shoreline along the base of the Wasatch Range (Machette, 1992) (table 1).

The surficial materials in the Springville quadrangle were mostly deposited by latest Pleistocene Lake Bonneville (Currey and Oviatt, 1985; Oviatt and others, 1992), in part contemporaneously with the last glacial advance, the Pinedale glaciation. Lips and others (2005) date the Pinedale maxima from about 17 to 15 ka based on ^{10}Be exposure ages measured from moraines at Little Cottonwood Canyon in the Wasatch Range.

Other surficial deposits in the quadrangle are mostly younger than Lake Bonneville and reflect post-glacial landscape evolution. Incision of the lake's threshold in southern Idaho and warming climatic conditions reduced the size of Lake Bonneville, leaving Utah Lake as one of its remnants stranded in Bonneville sub-basins (Jarrett and Malde, 1987; O'Conner, 1993). Younger stream alluvium, deposited as the lake level fell, forms extensive terraces on the Lake Bonneville delta at the mouth of Hobble Creek in the southern part of the Springville quadrangle. Streams incised in response to the lowering lake level, depositing small alluvial fans at the mouths of range-front drainages. Locally, steeper slopes underlain by shoreline deposits of Lake Bonneville failed, with some slope failures perhaps associated with earthquakes on the Wasatch fault zone; this process of landsliding continues sporadically today. On gentler slopes, a possible earthquake-induced lateral spread formed south of Springville, followed by headward erosion of scarps due to spring sapping and minor landsliding on locally steeper slopes of small alcoves surrounding springs. Wind eroded the desiccated Bonneville lake beds and deposited a thin but widespread mantle of calcareous loess on stable geomorphic surfaces. The loess is friable to moderately firm, homogenous, nonstratified, and porous, and forms steep to vertical faces where exposed in stream cuts; most argillic B horizons of late Pleistocene age soils in the region are derived from this loess (Machette, 1992). The loess is from 3 to 5 feet (1-1.5 m) thick. Small dunes were locally derived from sandy Lake Bonneville beach deposits.

Lake Bonneville

Sediments deposited by Pleistocene Lake Bonneville dominate the surficial geology of the Springville quadrangle. Lake Bonneville was a large pluvial lake that covered much of northwestern Utah between about 32,500 and 11,600 calendar years ago (references and radiocarbon ages for this discussion of the chronology of Lake Bonneville are shown in table 1; Oviatt and Thompson [2002] summarized many recent changes in the interpretation of Lake Bonneville radiocarbon chronology). Four regionally extensive shorelines of Lake Bonneville are found in the Bonneville Basin (Gilbert, 1890), but only the two most prominent (the Bonneville and Provo shorelines) are mapped in the quadrangle (table 1). The earliest of the regional shorelines is the Stansbury, which resulted from a climatically induced lake-level oscillation from about 24,400 to 23,200 years ago during expansion of Lake Bonneville. The Stansbury shoreline formed at elevations below those in the quadrangle. The lake continued to rise, entering Utah Valley from the north at an elevation of about 4500 feet (1370 m) about 23,000 years ago. In the Bonneville Basin, the lake reached its highest level of about 5092 feet (1552 m) about 18,000 years ago; this level was controlled by an overflow threshold near Zenda, in southern Idaho. This highstand created the Bonneville regional shoreline. In the Springville quadrangle, the Bonneville shoreline forms the highest bench near the base of the Wasatch Range.

About 16,800 years ago, overflow and rapid erosion at the Zenda threshold resulted in catastrophic lowering of the lake by 340 feet (100 m) (Jarrett and Malde, 1987) in less than one year (O'Conner, 1993). Lake Bonneville then stabilized at a new lower threshold near Red Rock Pass, Idaho, and the Provo regional shoreline was formed on piedmont slopes in the quadrangle.

The lake oscillated at or near the Provo level until about 13,500 years ago (Godsey and others, 2005), when climatic factors induced further lowering of the lake level within the Bonneville Basin. As Lake Bonneville fell below the altitude of the natural threshold of Utah Valley at the northern end of Utah Lake, Utah Lake became isolated from the main body of Lake Bonneville (Machette, 1992). By about 13,000 years ago, the level of Lake Bonneville had fallen below the elevation of present Great Salt Lake, but a subsequent expansion of Lake Bonneville from about 12,800 to 11,600 years ago formed the Gilbert shoreline. During the Gilbert expansion of Lake Bonneville, threshold control of the level of Utah Lake prevented the lake level from similarly rising (Machette, 1992). By Holocene time (about 10,000 years ago) Lake Bonneville had fallen to near the current level of Great Salt Lake, leaving Great Salt Lake and Utah Lake as its two most prominent remnants.

Isostatic rebound following overflow of Lake Bonneville, as well as displacement along the Wasatch fault zone, uplifted regionally extensive shorelines in the Bonneville basin (Crittenden, 1963; Currey, 1982). The amount of isostatic uplift increases toward the center of the basin where the volume of removed water was greatest; Crittenden (1963) estimated a maximum isostatic uplift of 210 feet (64 m) near the Lakeside Mountains west of Great Salt Lake. Machette (1992) reported combined isostatic and fault uplift of the Bonneville and Provo shorelines as much as 110 feet (34 m) and 65 feet (20 m), respectively, along the Wasatch fault zone in eastern Utah Valley. In the Springville quadrangle, combined isostatic and fault uplift of both shorelines on the footwall of the fault approaches the maximum recorded by Machette (1992). The maximum elevation of the Bonneville shoreline in the Springville quadrangle is about 5195 feet (1585 m) compared to its threshold elevation of 5092 feet (1552 m) at Zenda, and the maximum elevation of the Provo shoreline in the quadrangle is about 4800 feet (1465 m) compared to its threshold elevation of 4737 feet (1444 m) at Red Rock Pass (table 1). Thus, the combined uplift of the Bonneville and Provo shorelines in the quadrangle is about 103 feet (33 m) and 63 feet (21 m), respectively.

Paleoseismology

Utah Valley is a Neogene structural basin formed by late Cenozoic displacement along the Wasatch fault zone. Quaternary displacement indicates significant seismic hazards in the quadrangle, with potential earthquakes from moment magnitude 7.0 to 7.5 (Machette and others, 1992; Wells and Coppersmith, 1994). Data from paleoseismic trench exposures at Rock Canyon in the adjacent Orem quadrangle indicate that the most recent earthquake was about this magnitude and produced 10.8 feet (3.3 m) of net vertical tectonic displacement of the ground surface (Lund and Black, 1998). Based on currently available information on earthquake timing and displacement, the preferred vertical slip-rate estimate for the Provo segment is 1.2 mm/yr (with a possible range from 0.6 to 3.0 mm/yr) (Lund, 2005). Lund (2005) indicated the three most recent surface-faulting events occurred on the segment at 600 ± 350 cal yr B.P., 2850 ± 650 cal yr B.P., and 5300 ± 300 cal yr B.P., with a preferred recurrence-interval estimate of 2400 years (possibly ranging from 1200 to 3200 years). However, preliminary results from new trenching in the Spanish Fork Peak quadrangle in Mapleton (NE1/4 section 23, T. 8 S., R. 3 E., Salt Lake Baseline and Meridian [SLBLM]) indicate that the interval from the middle Holocene to latest Pleistocene may include several more surface-faulting earthquakes, and an additional late Holocene earthquake at about 1600 cal yr B.P. (Olig and others, 2004). These results suggest a much shorter recurrence interval for major earthquakes in Utah Valley.

Many paleoseismic investigations have been conducted in the area, including one in the Springville quadrangle. Swan and others (1980) profiled scarps where the main fault trace crosses a large alluvial-fan complex near the mouth of Hobble Creek Canyon (SW1/4 section 1 and NW1/4 section 12, T. 8 S., R. 3 E., SLBLM), and excavated three trenches about 1.2 miles (2 km) northwest of Hobble Creek at Deadmans Hollow (NE1/4 section 2, T. 8 S., R. 3 E., SLBLM). Collectively, the study area showed evidence for six or seven surface-faulting events since about 14.3 ka (Machette, 1992). The trenches revealed colluvial stratigraphy indicating three young events, and three or four older events are inferred from tectonic strath terraces preserved along Hobble Creek upstream from the fault zone, but the absence of organic material in the trenches and terraces prevented dating faulting events.

Liquefaction-Induced Landsliding

Saturated sandy sediments that are prone to liquefaction during moderate and large earthquakes generated by the Wasatch fault zone underlie much of Utah Valley. Large earthquake-induced slope failures initiated by liquefaction can pose a hazard to life as well as property. Thirteen features thought to be liquefaction-induced landslides have been identified along the Wasatch Front (from Brigham City to Nephi) by previous researchers. Harty and Lowe (2003) conducted geologic investigations of these features, one of which is partly within our map area.

Referred to as the Springville/Spanish Fork feature by Harty and Lowe (2003), the feature was first mapped as a lateral spread by Miller (1982), remapped with revised boundaries by Machette (1992), and mapped by Harty and Lowe (2003) using the boundaries of Machette (1992) but with additional detail. The feature is in the southwest corner of the Springville quadrangle, and extends southwest to the southeast corner of the Provo quadrangle (Solomon and Machette, 2008) and the northeast corner of the Spanish Fork quadrangle (Solomon and others, 2007); in total, it covers about 1.4 square miles (3.6 km^2). Although genetic interpretations other than lateral spreading are possible, the feature is mapped here as a possible lateral-spread deposit because it is in an area having high liquefaction potential (Anderson and others, 1986). Until definitive evidence eliminates earthquake-induced liquefaction as its cause, for purposes of assessing geologic hazards it is prudent to consider the feature to be a lateral-spread deposit. The presence of shallow ground water and granular soils near the margin of Utah Valley, with high levels of seismicity on the Wasatch fault zone, suggests that large-scale liquefaction may have occurred repeatedly in the region.

The Springville/Spanish Fork feature extends for about 2.5 miles (4 km) parallel to the toe of the Lake Bonneville delta at the mouth of Spanish Fork Canyon. Rather than a continuous main scarp, the feature includes several small, discontinuous, arcuate scarps as much as 3 feet (1 m) high on their upslope edges, each no more than 0.5 mile (0.8 km) long. The feature is characterized by a few isolated hummocks and small depressions with relief of less than about 3 feet (1 m) and larger, flat-topped erosional remnants of transgressive lacustrine silt and clay. Harty and Lowe (2003) mapped two discontinuous lineaments within the feature that they interpreted to be regressive shorelines of Lake Bonneville; we agree with this interpretation and map a third lineament farther to the east that lies within 200 feet (60 m) of State Route 156. This third lineament coincides with discontinuous linear scarps of unknown origin mapped by Harty and Lowe (2003) on the upslope edge of the feature, and which we interpret as another regressive shoreline.

Harty and Lowe (2003) excavated three trenches across their two lineaments. Two of the trenches (SP-1 and SP-2, SW1/4 and SE1/4 section 8, T. 8 S., R.3 E., SLBLM) showed no evidence of liquefaction or soil deformation, and the third trench (SP-3, NW1/4 section 8, T. 8 S., R.3 E., SLBLM) showed no direct evidence of liquefaction but exhibited faults with minor displacements of a few centimeters. Despite the lack of deformation in two trenches and only minor brittle deformation in the third, Harty and Lowe (2003) mapped the entire feature as possible deposits of liquefaction-induced landsliding. We restrict possible landslide deposits to the small, isolated hummocks within swampy areas and larger outcrops that lie across the discontinuities of the lineaments and show no evidence of shorelines. We exclude the flat-topped erosional remnants because they exhibit greater relief than potential lateral-spread deposits, reflecting an erosional resistance similar to transgressive silt and clay mapped elsewhere, and their downslope margins coincide with lacustrine shorelines. Harty and Lowe (2003) suggested that one mechanism for preservation of the lineaments was headward erosion due to spring sapping, which ceased when relatively resistant gravels were encountered along a lacustrine shoreline; we believe that this mechanism is responsible for the lineaments in the Springville/Spanish Fork feature and for preservation of upslope lake deposits.

Previous Investigations

Numerous geologic studies of the Springville quadrangle date back one-half century. Hintze (1962) compiled a small-scale bedrock map of the southern Wasatch Range and later mapped the geology of the area surrounding Brigham Young University in more detail (Hintze, 1978). Bissell (1963) conducted the first geologic mapping of surficial Quaternary deposits in the region, and Miller (1982) remapped the deposits. Machette (1992) mapped the surficial geology of eastern Utah Valley as part of a program by the U.S. Geological Survey to map the surficial geology of the active Wasatch fault zone, and Harty and Lowe (2003) conducted geologic evaluations of liquefaction-induced landslides along the Wasatch Front, including an evaluation of the Springville/Spanish Fork feature in the southwest corner of the Springville quadrangle. Baker (1973) mapped the geology of the Springville quadrangle at a scale of 1:24,000 and Constenius and others (2006) conducted regional-scale mapping of bedrock in the Springville quadrangle and adjacent areas.

This mapping effort is part of a larger project to map the Provo 30' x 60' quadrangle (Constenius and others, 2006), during which geology of the adjacent Spanish Fork (Solomon and others, 2007) and Provo (Solomon and Machette, 2008) quadrangles were mapped. Other quadrangles mapped during the project include Saratoga Springs (Biek, 2004), GoshenValley North (Clark and others, 2006), Soldiers Pass (Biek and others, 2006), West Mountain (Clark, 2006), and Lincoln Point (Solomon and Biek, 2008). Solomon also mapped the Quaternary geology of part of the Spanish Fork Peak quadrangle in 2006 (unpublished), and mapping of the Quaternary geology of the Pelican Point, Orem, and Bridal Veil Falls quadrangles is ongoing (figure 2).

ACKNOWLEDGEMENTS

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MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial deposits

Qal_1 **Level-1 stream deposits** (upper Holocene) – Moderately sorted pebble and cobble gravel in a matrix of sand, silt, and minor clay; contains thin discontinuous sand lenses; subangular to rounded clasts; thin to medium bedded. Deposited by perennial streams such as Hobble Creek and Spring Creek, and by smaller streams draining areas of shallow ground water and marshes south of Springville; includes deposits on active flood plains and minor terraces less than 5 feet (1.5 m) above stream level; locally includes minor colluvial deposits along steep stream embankments; equivalent to the younger part of young stream deposits (Qaly), but differentiated where modern deposits with active channels and bar-and-swale topography can be mapped separately. Exposed thickness less than 15 feet (5 m).

Qaly **Young stream deposits, undivided** (Holocene to upper Pleistocene) – Moderately sorted pebble and cobble gravel in a matrix of sand and minor silt and clay. Deposited in braided streams that diverge westward from Hobble Creek about 1.5 miles (2.4 km) west of the Wasatch Range and 2 miles (3.2 km) farther northwest on the surface of low-gradient alluvial-fans (Qafy), and deposited by perennial streams in mountain canyons and small, ephemeral streams on the valley floor; locally includes small alluvial-fan and colluvial deposits; includes upper Pleistocene to middle Holocene stream deposits (level-2 stream deposits) incised by active stream channels and partly overlain by level-1 stream deposits (Qal_1) that cannot be differentiated because of map scale or in areas where the specific age of Holocene deposits cannot be determined, but mappable exposures of level-2 stream deposits (Qal_2) are not found in the Springville quadrangle; postdates regression of Lake Bonneville from the Provo shoreline and lower levels. Thickness variable, probably less than 15 feet (5 m).

Qalp **Stream deposits, regressive (Provo) phase of Lake Bonneville** (upper Pleistocene) – Poorly to moderately sorted pebble and cobble gravel in a matrix of sand, silt, and minor clay; contains thin discontinuous sand lenses; subangular to rounded clasts; thin to medium bedded. Deposited southwest of Maple Canyon above the Provo shoreline in channels incised into silt and clay of the transgressive phase of Lake Bonneville (Qlmb), where it is truncated by level-2 alluvial-fan deposits (Qaf_2) and graded to terraces formed by Hobble Creek during the regressive phase of Lake Bonneville (Qat_5); adjacent deposits in the Spanish Fork Peak quadrangle to the south are graded to the Provo shoreline (Solomon, unpublished mapping, 2006). Equivalent to the younger part of level-3 stream deposits (Qal_3), but differentiated where relationships with Lake Bonneville shorelines and alluvial and lacustrine deposits can be determined. Exposed thickness less than 15 feet (5 m).

Qalb **Stream deposits, transgressive (Bonneville) phase of Lake Bonneville** (upper Pleistocene) – Poorly to moderately sorted pebble and cobble gravel in a matrix of sand, silt, and minor clay; contains thin discontinuous sand lenses; subangular to rounded clasts; thin to medium bedded. Remnants are preserved: (1) on the north side of the mouth of Hobble Creek Canyon in a small, unnamed drainage southeast of Deadmans Hollow, where they were deposited above, and are graded to, the Bonneville shoreline, and (2) at the mouth of Maple Canyon, deposited slightly below the Bonneville shoreline. Equivalent to the older part of level-3 stream deposits (Qal_3), but differentiated where the relationship to the Bonneville shoreline can be determined. Exposed thickness less than 15 feet (5 m).

Qal_3 **Level-3 stream deposits** (upper Pleistocene) – Moderately sorted pebble and cobble gravel in a matrix of sand and minor silt and clay. One remnant is preserved in Maple Canyon, incised by the active stream channel and partly overlain by young alluvial-fan deposits (Qaly), but its relationship to shorelines of Lake Bonneville cannot be determined. Thickness variable, probably less than 15 feet (5 m).

Qat_{1-5} **Stream-terrace deposits** (middle Holocene to upper Pleistocene) – Poorly to moderately sorted pebble and cobble gravel in a matrix of sand, silt, and minor clay; contains thin sand lenses; subangular to rounded clasts; thin to medium bedded. Deposited on as many as five levels of gently sloping terraces, with subscripts denoting relative position above modern stream channels in downcutting sequence, 1 being the lowest level; level 1 deposits (Qat_1) lie 5 to 15 feet (1.5-5 m) above modern streams and are incised by them; levels 2 through 5 lie at increasing relative heights of 30 to 40 feet (9-12 m) (Qat_2), 40 to 50 feet (12-15 m) (Qat_3), 50 to 60 feet (15-18 m) (Qat_4), and 60 to 75 feet (18-23 m) (Qat_5) above modern streams; numbered subscripts do not indicate specific age. Smaller terrace remnants are mapped at the mouth of Maple Canyon, but the most extensive deposits are on regressive Lake Bonneville deltaic deposits (Qldp) and sand and silt (Qlsp) as far as 2.5 miles (4.0 km) from the mouth of Hobble Creek Canyon where Machette (1992) mapped them as regressive-phase stream alluvium. Thicknesses typically 5 to 15 feet (1.5-5 m) for each map unit.

Qaf_1 **Level-1 alluvial-fan deposits** (upper Holocene) – Poorly to moderately sorted, weakly to non-stratified, pebble to cobble gravel, with boulders near bedrock sources, in a matrix of sand, silt, and minor clay; clasts angular to subrounded, with sparse well-rounded clasts derived from Lake Bonneville gravel; medium to very thick bedded. Deposited by debris flows, debris floods, and streams at the mouths of small, intermittent stream channels that drain bedrock in the Wasatch Range; equivalent to the younger part of young alluvial-fan deposits (Qafy) but differentiated where modern deposits of small, active, discrete fans are not incised by younger channels, overlie lacustrine and older Holocene alluvial-fan deposits, and can be mapped separately. Exposed thickness less than 10 feet (3 m).

Qaf_2 **Level-2 alluvial-fan deposits** (middle Holocene to upper Pleistocene) – Poorly sorted pebble and cobble gravel, locally bouldery, in a matrix of sand, silt, and minor clay; clasts angular to subrounded, with sparse well-rounded clasts derived from Lake Bonneville gravel; medium to very thick bedded. Deposited by debris flows, debris floods, and streams from canyons in the Wasatch Range southeast of Springville; equivalent to the older part of Qafy, but differentiated where deposits are graded slightly above modern stream level or are at the mouth of an abandoned stream channel, and can be mapped separately. Exposed thickness less than 15 feet (5 m).

Qafy **Young alluvial-fan deposits, undivided** (Holocene to upper Pleistocene) – Poorly to moderately sorted, pebble to cobble gravel with boulders near bedrock sources, in a matrix of sand, silt, and clay, grading to mixtures of sand, silt, and clay on gentler slopes. Deposited by debris flows, debris floods, and streams at the mouths of large and small mountain canyons and streams locally incising Lake Bonneville deposits, where deposits typically form a coalesced apron at the base of the Wasatch Range; also deposited by debris floods and streams on broad areas of the valley floor where Hobble Creek lost confinement west of its channel incised into regressive Lake Bonneville deltaic deposits (Qldp). Includes level-1 and 2 alluvial-fan deposits (Qaf_1 and Qaf_2) that postdate the regression of Lake Bonneville from the Provo shoreline and lower levels but cannot be differentiated because of map scale or are in areas where the specific age of Holocene deposits cannot be determined; no Lake Bonneville shorelines are found on these alluvial fans. Thickness variable, probably less than 40 feet (12 m).

Qafp **Alluvial-fan deposits, regressive (Provo) phase of Lake Bonneville** (upper Pleistocene) – Poorly to moderately sorted, pebble to cobble gravel, locally bouldery, in a matrix of sand, silt, and minor clay; clasts angular but well rounded where derived from Lake Bonneville gravel; medium to very thick bedded. Deposited by debris flows, debris floods, and stream flow: (1) near the Provo shoreline at the mouth of Slate Canyon, incised into transgressive Lake Bonneville gravel and sand (Qlgb), and (2) at the mouth of a small, unnamed canyon between Provo and Springville, etched by a regressive Lake Bonneville shoreline that is below, and postdates, the Provo shoreline, and partly covered by level-1 alluvial-fan deposits (Qaf_1). Equivalent to the younger part of level-3 alluvial-fan deposits (Qaf_3) mapped north of Orem and southeast of Spanish Fork City by Machette (1992), but differentiated where deposits related to the regressive phase of Lake Bonneville, typically below the Bonneville shoreline, can be separated from deposits related to the transgressive phase of the lake, typically above the Bonneville shoreline; level-3 alluvial-fan deposits are not mapped in the Springville quadrangle because all mapped alluvial-fan deposits in the quadrangle related to Lake Bonneville are associated with the regressive lake phase and none are suspected to have a relationship with the transgressive phase. The B soil horizon of paleosols developed on regressive-phase alluvial-fan deposits commonly shows an intensification of brown colors due to oxidation of iron-bearing minerals or a slight accumulation of clay, and may include a pedogenic accumulation of calcium carbonate as thin, discontinuous coatings on gravel; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of this unit and others of similar age as A/Bw/Bk(or Cox) to A/Bt(weak)/Bk(or Cox). Exposed thickness less than 30 feet (10 m).

Qaf_4 **Level-4 alluvial-fan deposits, pre-Bonneville lake cycle to Little Valley lake cycle** (upper to middle Pleistocene) – Poorly sorted, clast-supported pebble to cobble gravel, with matrix-supported interbeds in the upper part; locally bouldery in a matrix of sand, silt, and clay; clasts angular to subrounded; medium to very thick bedded. Deposits are found near the mouths of small canyons north of Springville, above and below the Bonneville shoreline; commonly covered by a thin veneer of regressive gravel and sand (Qlgp) below the Provo shoreline, reworked from the underlying alluvial fan. Machette (1992) stated that correlative deposits likely underlie Lake Bonneville deposits, forming the piedmont slopes within Utah Valley, and probably grade laterally to lacustrine sediment of the Little Valley lake cycle below an elevation of about 4900 feet (1490 m) (Scott and others, 1983). Equivalent to the younger part of older alluvial-fan deposits (Qafo) but differentiated where pre-Bonneville deposits can be divided into Qaf_4 and Qaf_5 based on fan morphology, degree of dissection, and incision of younger into older deposits. The B soil horizon of paleosols developed on level-4 alluvial-fan deposits commonly shows a moderate accumulation of clay, gravel is typically coated with calcium carbonate, and calcium carbonate may occur in significant accumulations between clasts; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of this unit and others of similar age as A/Bt(moderate)/Bk(stage II-III)/Cox. Exposed thickness less than 15 feet (5 m).

Qaf_5 **Level-5 alluvial-fan deposits, pre-Little Valley lake cycle** (middle Pleistocene) – Poorly sorted, clast-supported pebble to cobble gravel, with matrix-supported interbeds in the upper part; locally bouldery, in a matrix of sand, silt, and clay; deposits are exposed near the mouth of a small, unnamed canyon south of Buckley Draw and north of Springville, partly incised by level-4 alluvial-fan deposits. Machette (1992) reported that level-5 alluvial-fan deposits exposed in a stream gully on the divide east of Peteetneet Creek in the Payson Lakes quadrangle contain isolated pods of 0.62 Ma Lava Creek B volcanic ash (Izett and Wilcox, 1982, Utah locality 9). Correlative alluvial deposits likely underlie Lake Bonneville deposits and probably grade laterally to lacustrine sediment of the Pokes Point and other lake cycles older than the Little Valley lake cycle (Scott and others, 1983; Machette and Scott, 1988), although not observed in Utah Valley (Machette, 1992). Equivalent to the older part of older alluvial-fan deposits (Qafo) but differentiated where Little Valley and pre-Little Valley deposits can be separated based on incision of younger into older deposits. The B soil horizon of paleosols developed on level-5 alluvial-fan deposits commonly shows a significant accumulation of clay, gravel is typically coated with calcium carbonate, and calcium carbonate may occur in significant accumulations between clasts or as cement; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of this unit and others of similar age as

A/Bt(strong)/Bk(stage II-III)/K(stage II)/Cox. Exposed thickness less than 15 feet (5 m).

Qafo **Older alluvial-fan deposits, pre-Bonneville lake cycle, undivided** (upper to middle Pleistocene) – Poorly sorted, pebble to cobble gravel, locally bouldery, in a matrix of sand, silt, and clay. Mapped along the Wasatch Range front northward from Round Peak in the Springville quadrangle, where pre-Bonneville lake cycle alluvial-fan deposits (Qaf_4 and Qaf_5) are undifferentiated because they are poorly exposed or lack distinct geomorphic expression. However, deposits mapped by Machette (1992) as Qafo on range-front spurs in the footwall of the Wasatch fault zone above an elevation of about 5200 feet (1600 m) within about 0.8 miles (1.3 km) northwest of Little Rock Canyon are remapped as Paleozoic sedimentary rock (Pz); these rocks were mapped as the Deseret Limestone of Late Mississippian age by Baker (1973), who interpreted them as occurring in the hanging wall of the Wasatch fault zone which, at this location, dips at a shallow angle measured by Baker (1973) as ranging from 30 to 35 degrees; Baker (1973) measured an attitude in an exposure of Deseret Limestone at this location of N. 33° W., 77° SW. The B soil horizon of paleosols developed on these deposits commonly shows a moderate to significant accumulation of clay, gravel is typically coated with calcium carbonate, and calcium carbonate may occur either as significant accumulations between clasts or as cement; Machette (1992), using the terminology of Birkeland (1984), designated the soil profiles of the differentiated units as A/Bt(moderate)/Bk(stage II-III)/Cox and A/Bt(strong)/Bk(stage II-III)/K(stage II)/Cox. Thickness probably less than 60 feet (20 m).

Fill deposits

Qf **Artificial fill** (Historical) – Engineered fill used in the construction of dikes and dams for debris basins and irrigation-water ponds; unmapped fill is locally present in all developed areas but only the largest deposits are mapped. Maximum thickness about 20 feet (6 m).

Qfd **Disturbed land** (Historical) – Land disturbed by sand, gravel, and aggregate operations and by excavation of debris basins and ponds; only the larger sand, gravel, and aggregate operations are mapped and their outlines are based on aerial photographs taken in 1965 and 2002; many sites have since been regraded and developed, and may contain unmapped deposits of artificial fill (Qf). Land within these areas contains a complex, rapidly changing mix of cuts and fill deposits; most operations extracted material from transgressive lacustrine gravel and sand (Qlgb) and alluvial-fan deposits older than Lake Bonneville (Qaf_4 and Qafo). Thickness unknown.

Colluvial deposits

Qc **Colluvial deposits** (Holocene to upper Pleistocene) – Pebble, cobble, and boulder gravel, commonly clast supported, in a matrix of sand, silt, and clay; angular to subrounded clasts, poorly sorted, poorly stratified, locally derived sediment deposited by slopewash and soil creep at the base of the steep slope on the north side of the Hobble Creek Canyon mouth; because many bedrock slopes are covered by at least a veneer of colluvium, only the larger, thicker deposits are mapped. Maximum thickness about 20 feet (6 m).

Lacustrine deposits

Deposits younger than the Bonneville lake cycle: Only mapped below the Utah Lake highstand elevation of about 4495 to 4500 feet (1370-1372 m) (table 1).

Qlmy **Young lacustrine silt and clay** (Holocene to upper Pleistocene) – Silt, clay, and minor fine-grained sand deposited near the inlet of Spring Creek into Provo Bay along the west-central edge of the quadrangle; locally organic rich; overlies sediments of the Bonneville lake cycle. Brimhall and others (1976) reported that Holocene gray clayey silt composed mostly of calcite forms the upper 15 to 30 feet (5-10 m) of the lake sediments in Utah Lake.

Deposits of the regressive (Provo) phase of the Bonneville lake cycle: Only mapped below the Provo shoreline, which is at elevations from about 4750 to 4800 feet (1450-1465 m) in the quadrangle (table 1). The B soil horizon of paleosols developed on regressive-phase lacustrine deposits commonly shows an intensification of brown colors due to oxidation of iron-bearing minerals or a slight accumulation of clay, and may include a pedogenic accumulation of calcium carbonate as filaments in fine-grained soil or thin, discontinuous coatings on gravel; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of these units as A/Bw/Bk(or Cox) to A/Bt(weak)/Bk(or Cox).

Qldp **Deltaic deposits** (upper Pleistocene) – Moderately to well-sorted, clast-supported, pebble and cobble gravel in a matrix of sand and silt; interbedded with thin pebbly sand beds; clasts subrounded to rounded; locally weakly cemented with calcium carbonate. Deposited as bottomset beds having original dips of 1 to 5 degrees and overlying foreset beds having original dips of 30 to 35 degrees; present in a delta below the Provo shoreline at the mouth of Hobble Creek; commonly capped by a thin veneer of stream-terrace deposits (Qat) and exposed along terrace escarpments and the delta front. Exposed thickness about 75 feet (25 m).

Qlgp **Lacustrine gravel and sand** (upper Pleistocene) – Moderately to well-sorted, subrounded to rounded, clast-supported, pebble to cobble gravel and pebbly sand with minor silt. Gastropods locally common in sandy lenses; gravel commonly cemented with calcium carbonate; thin to thick bedded. Near the base of the Wasatch Range, deposits typically form wave-cut or wave-built benches, bars, barrier beaches, and beach ridges; wave-cut benches are commonly partly covered by colluvium derived from adjacent oversteepened slopes. Bedding ranges from horizontal to primary dips of 10 to 15 degrees on steeper piedmont slopes or in bars, barrier beaches, and beach ridges; intermediate regressive shorelines are locally well developed on Provo-level deposits; commonly interbedded with or laterally gradational to lacustrine sand and silt of the regressive phase (Qlsp). Exposed thickness less than 30 feet (10 m).

Qlsp **Lacustrine sand and silt** (upper Pleistocene) **–** Moderately to well-sorted, subrounded to rounded, fine to coarse sand and silt with minor pebbly gravel. Thick to very thick bedded, commonly laminated, with some ripple marks and scour features; gastropods locally common. Deposited in relatively shallow water near shore; overlies and grades downslope into lacustrine silt and clay of the regressive phase (Qlmp), grades laterally to sandy deltaic deposits (Qldp), and forms linear barrier beaches on deltaic deposits (Qldp); locally buried by loess veneer. Exposed thickness less than 30 feet (10 m).

Qlmp **Lacustrine silt and clay** (upper Pleistocene) **–** Calcareous silt (marl) and clay with minor fine sand; typically laminated or thin bedded; ostracodes locally common. Deposited in quiet water in moderately deep parts of the Bonneville basin and in sheltered bays; overlies lacustrine silt and clay of the transgressive phase (Qlmb) and grades upslope into lacustrine sand and silt (Qlsp); locally buried by loess veneer; regressive lacustrine shorelines typically poorly developed. Forms small, irregular erosional remnants surrounded by distal alluvial-fan deposits (Qafy) and stream alluvium (Qaly and Qal_1) east of Provo Bay, and larger, continuous deposits downslope of Hobble Creek deltaic deposits (Qldp). Machette (1992) reported that silt and clay of the regressive phase can be differentiated from silt and clay of the transgressive phase by the presence of conchoidal fractures in blocks of transgressive deposits and their absence in regressive deposits, but Qlmp may include some undifferentiated transgressive deposits. Exposed thickness less than 15 feet (5 m), but total thickness may exceed several tens of feet.

Deposits of the transgressive (Bonneville) phase of the Bonneville lake cycle: Mapped between the Bonneville and Provo shorelines. The Bonneville shoreline is at elevations from about 5140 to 5195 feet (1565-1585 m) in the quadrangle (table 1). The B soil horizon of paleosols developed on transgressive-phase lacustrine deposits commonly shows a slight to moderate accumulation of clay and may include a pedogenic accumulation of calcium carbonate as filaments in fine-grained soil or thin, discontinuous coatings on gravel; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of these units as A/Bt/Bk(or Cox).

Qlgb **Lacustrine gravel and sand** (upper Pleistocene) **–** Moderately to well-sorted, clast-supported pebble to cobble gravel in a matrix of sand and silt; locally interbedded with thin to thick beds of silt and pebbly sand. Clasts commonly subrounded to rounded, but some deposits consist of poorly sorted, angular gravel derived from nearby bedrock outcrops. Gastropods locally common in sandy lenses; gravel locally cemented with calcium carbonate (tufa). Thin to thick bedded; bedding ranges from horizontal to primary dips of 10 to 15 degrees on steeper piedmont slopes or in bars, barrier beaches, and beach ridges; interbedded with or laterally gradational to lacustrine sand and silt of the transgressive phase (Qlsb) east and southeast of Springville; commonly covered by a thin veneer of colluvium. Commonly present on wave-cut benches at the highest (Bonneville) shoreline in bedrock near the base of the Wasatch Range. Exposed thickness less than 30 feet (10 m).

Qlsb **Lacustrine sand and silt** (upper Pleistocene) **–** Moderately to well-sorted, subrounded to rounded, fine to coarse sand and silt with minor pebbly gravel. Thick to very thick bedded; commonly has ripple marks and scour features; gastropods locally common. Deposited in relatively shallow water near shore; overlies coarse-grained beach gravel (Qlgb), implying deposition in increasingly deeper water of a transgressing lake. Mapped east and southeast of Springville. Exposed thickness less than 15 feet (5 m).

Qlmb **Lacustrine silt and clay** (upper Pleistocene) **–** Calcareous silt (marl) and clay with minor fine sand; typically thick bedded or very thick bedded; ostracodes locally common. Deposited in quiet water, either in sheltered bays between headlands or offshore in deeper water; overlies lacustrine gravel, sand, and silt of the transgressive phase (Qlgb and Qlsb). Mapped southwest of Maple Canyon on the south edge of the Springville quadrangle where incised by stream channels of the regressive phase of Lake Bonneville, and in small exposures along stream-terrace edges to the north along Hobble Creek. Exposed thickness less than 15 feet (5 m).

Eolian deposits

Qes **Eolian sand** (Holocene to upper Pleistocene) **–** Moderately to well sorted, very fine to medium sand, with minor silt and clay. Calcareous, loose to moderately firm where cemented by secondary calcium carbonate; forms thin blankets and small dunes; wind-blown sand derived from transgressive Bonneville beach sand (Qlsb) along the Wasatch Range front south of Hobble Creek. Thickness from 3 to 10 feet (1-3 m).

Mass-movement deposits

Qml? **Lateral-spread deposits?** (middle Holocene to upper Pleistocene) **–** Pebbly sand, sand, silt, and clay below (post-dating) the Provo shoreline, incised by spring-fed drainages from the southeast that converge in swampy swales. Referred to as the Springville/Spanish Fork feature by Harty and Lowe (2003). The feature lies mostly in the southeast corner of the Provo quadrangle (Solomon and Machette, 2008) and the southwest corner of the Springville quadrangle, extends southward into the adjacent Spanish Fork quadrangle (Solomon and others, 2007), and covers about 1.4 square miles (3.6 km^2). Although interpretations other than lateral spreading are possible, the feature is mapped here as possible lateral-spread deposits because it is in an area having high liquefaction potential (Anderson and others, 1986) (see the discussion of liquefaction-induced landsliding in the introduction of this report for more details). Thickness of the deposits is unknown but probably less than 50 feet (15 m).

Qms **Landslide deposits** (Historical to upper Pleistocene) – Poorly sorted, fine to medium sand, sandy silt, and pebble and cobble gravel in small slumps and earth flows mapped in widely scattered areas along the range front; derived from nearshore and deltaic deposits of Lake Bonneville; composition reflects local sources of material. Maximum thickness about 20 feet (6 m).

Qmd_1 **Level-1 debris-flow deposits** (upper Holocene) – Unsorted cobble and boulder gravel in a matrix of sand, silt, and clay; contains thin discontinuous sand or gravel lenses with as much as 3 percent organic matter (Machette, 1992); commonly covered with coarse, angular rubble and distinct levees and channels. Mapped at the mouth of a small, unnamed drainage north of Little Rock Canyon on the surface of older alluvial-fan deposits (Qafo). Thickness less than 15 feet (5 m).

Qmd_2 **Level-2 debris-flow deposits** (middle Holocene to upper Pleistocene) – Unsorted cobble and boulder gravel in a matrix of sand, silt, and clay; contains thin discontinuous sand or gravel lenses but most organic matter has been oxidized and not preserved (Machette, 1992); commonly covered with coarse, angular rubble but levees and channels are more indistinct than on level-1 debris-flows (Qmd_1). Mapped at the mouth of Maple Canyon on the surface of a level-2 alluvial fan (Qaf_2). Thickness less than 15 feet (5 m).

Qmdy **Young debris-flow deposits, undivided** (Holocene to upper Pleistocene) – Unsorted cobble and boulder gravel in a matrix of sand, silt, and clay; contains thin discontinuous sand or gravel lenses. Mapped at the mouth of unnamed drainages on the northwest side of Round Peak on the surface of regressive lacustrine deposits (Qlmp and Qlsp). Thickness less than 30 feet (10 m).

Qmt **Talus deposits** (Holocene to upper Pleistocene) **–** Very poorly sorted, angular cobbles and boulders and finer-grained interstitial sediment deposited principally by rock fall on or at the base of steep slopes; mapped along the Wasatch Range front, south of Slate Canyon and southeast of Round Peak. Generally less than 20 feet (6 m) thick.

Spring and marsh deposits

Qsm **Marsh deposits** (Holocene to upper Pleistocene) – Fine, organic-rich sediment associated with springs, ponds, seeps, and wetlands; commonly wet, but seasonally dry; may locally contain peat deposits as thick as 3 feet (1 m); overlies and grades into fine-grained lacustrine deposits (Qlmp); present where water table is high near Spring Creek and in the area of the Springville/Spanish Fork feature. Thickness commonly less than 10 feet (3 m).

Mixed-environment deposits

Qac **Alluvial and colluvial deposits, undivided** (Holocene to upper Pleistocene) – Poorly to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment mapped in a small wash at the base of the Wasatch Range north of Springville where deposits of alluvial, slopewash, and creep processes grade imperceptibly into one another; small, unmapped deposits are likely in most small drainages. Thickness less than 10 feet (3 m).

Qla **Lacustrine and alluvial deposits, undivided** (Holocene to upper Pleistocene) – Sand, silt, and clay in areas of mixed alluvial and lacustrine deposits that are undifferentiated because the units grade imperceptibly into one another; mapped near Ironton. Thickness less than 10 feet (3 m).

Stacked-unit deposits

Qlgp/Qaf_4

Lacustrine gravel and sand (regressive phase) over pre-Bonneville alluvial-fan deposits (upper Pleistocene/upper to middle Pleistocene) – A veneer of lacustrine gravel and sand related to the regressive phase of Lake Bonneville reworked from underlying alluvial-fan deposits older than Lake Bonneville but not older than the Little Valley lake cycle; mapped below the Provo shoreline at west of Buckley Draw. Lacustrine deposits are generally less than 3 feet (1 m) thick.

Qlgp/Qafo

Lacustrine gravel and sand (regressive phase) over older alluvial-fan deposits, undivided (upper Pleistocene/upper to middle Pleistocene) – A veneer of lacustrine gravel and sand related to the regressive phase of Lake Bonneville reworked from underlying undivided alluvial-fan deposits older than Lake Bonneville; mapped below the Provo shoreline along the Wasatch Range front west of Buckley Draw. Lacustrine deposits are generally less than 3 feet (1 m) thick.

Major unconformity

Bedrock mapping and unit descriptions are modified from Baker (1973), Hintze (1978), and Constenius and others (2006). We mapped bedrock only (1) below the Bonneville shoreline, locally exposed on steep slopes where no significant lacustrine deposition occurred, and (2) on range-front spurs northwest of Little Rock Canyon, where bedrock is found in the hanging wall of the shallow-dipping Wasatch fault zone.

PERMIAN – PENNSYLVANIAN

The Oquirrh Group/Formation was deposited in the Oquirrh marine basin of north-central Utah and southern Idaho, with fine arkosic sand derived principally from the Weber shelf and Uncompahgre Uplift (Welsh and Bissell, 1979). Terminology and subdivision of Oquirrh Group/Formation and associated Permian strata vary by thrust plate and location within the Oquirrh basin (Welsh and James, 1961; Tooker and Roberts, 1970; Swenson, 1975; Morris and others, 1977; Welsh and Bissell, 1979; Jordan and Douglas, 1980; Hintze, 1988, p. 34; Biek, 2004; Biek and Lowe, 2005) because a comprehensive regional study of the basin has not been conducted. Thus, differing terminology is commonly applied west and east of Utah and Salt Lake Valleys (figure 3). On the west side of the valleys, the Pennsylvanian strata of the Oquirrh Group are divided into three formations; these are, in ascending order, the West Canyon Limestone, Butterfield Peaks Formation, and Bingham Mine Formation. On the east side of the valleys, including the southern Wasatch Range in the Springville quadrangle, the Oquirrh Formation is divided into, in ascending order, four Pennsylvanian units: the Bridal Veil Limestone Member, Bear Canyon Member, Shingle Mill Limestone Member, and Wallsburg Ridge Member. The Oquirrh Formation also includes the Permian Granger Mountain Member (Baker and Crittenden, 1961; Baker, 1964a, 1972a).

All Members of the Oquirrh Formation are exposed in the Springville quadrangle (Baker, 1973; Constenius and others, 2006), but we map the Oquirrh Formation as undivided because the focus of our mapping is the Quaternary deposits. The Permian-Pennsylvanian Oquirrh Formation is about 26,000 feet (8000 m) thick near Mt. Timpanogos in the Wasatch Range (Baker and Crittenden, 1961).

PIPo **Oquirrh Formation, undivided** (Lower Permian [Wolfcampian] to Pennsylvanian) – As shown in the Springville quadrangle, only includes the Pennsylvanian Bear Canyon and Bridal Veil Limestone Members (Baker, 1973; Constenius and others, 2006).

PENNSYLVANIAN – PROTEROZOIC

PZ **Paleozoic and Proterozoic strata, undivided** (Lower Pennsylvanian? to Upper Proterozoic) – Sedimentary rocks include the Lower Pennsylvanian? to Upper Mississippian Manning Canyon Shale, Upper Mississippian Great Blue Limestone and Humbug Formation, Upper and Lower Mississippian Deseret Limestone, Lower Mississippian Gardison Limestone, Lower Mississippian and Upper Devonian Fitchville Formation, Middle Cambrian Maxfield Limestone, Middle Cambrian Ophir Formation, Middle to Lower Cambrian Tintic Quartzite, and Upper Proterozoic Mineral Fork Tillite and Big Cottonwood Formation (Baker, 1947, 1973; Hintze, 1978; Constenius and others, 2006).

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Table 1. *Ages of major shorelines of Lake Bonneville and Utah Lake and shoreline elevations in the Springville quadrangle.*

Lake Cycle and Phase	Shoreline (map symbol)	Age: radiocarbon years B.P.	Age: calendar years B.P.[1]	Elevation feet (meters)
Lake Bonneville				
Transgressive Phase	Stansbury	22,000-20,000[2]	24,400-23,200	Not present
	Bonneville (B)	15,500-14,500[3]	18,000-16,800	5140-5195 (1565-1585)
	flood			
Regressive Phase	Provo (P)	14,500-12,000[4]	16,800-13,500[5]	4750-4800 (1450-1465)
	Gilbert	11,000-10,000[6]	12,800-11,600	Not present
Utah Lake				
	Utah Lake highstand (U)	12,000-11,500[7]	-----	4495-4500 (1370-1372)

[1]Calendar-calibrated ages of most shorelines have not been published. Calendar-calibrated ages shown here, except for the age of the end of the Provo shoreline, are from D.R. Currey, University of Utah (written communication to Utah Geological Survey, 1996; cal yr B.P. = 1.16 ^{14}C yr B.P.).

[2]Oviatt and others (1990). Currey (written communication to Utah Geological Survey, 1996) assumed a maximum age for the Stansbury shoreline of 21,000 ^{14}C yr B.P., which is used in the conversion to calendar years.

[3]Oviatt and others (1992), Oviatt (1997).

[4]Godsey and others (2005) revised the timing of the occupation of the Provo shoreline and subsequent regression; Oviatt and others (1992) and Oviatt (1997) proposed a range from 14,500 to 14,000 ^{14}C yr B.P. Oviatt and Thompson (2002) summarized many recent changes in the interpretation of the Lake Bonneville radiocarbon chronology.

[5]Calendar-calibrated age of the end of the Provo shoreline estimated by interpolation from data in Godsey and others (2005), table 1, who used Stuiver and Reimer (1993) for calibration.

[6]Murchison (1989), figure 20.

[7]Estimated from data in Godsey and others (2005); Machette (1992) estimated the age of the regression of Lake Bonneville below the Utah Valley threshold at 13,000 ^{14}C yr B.P. from earlier data.

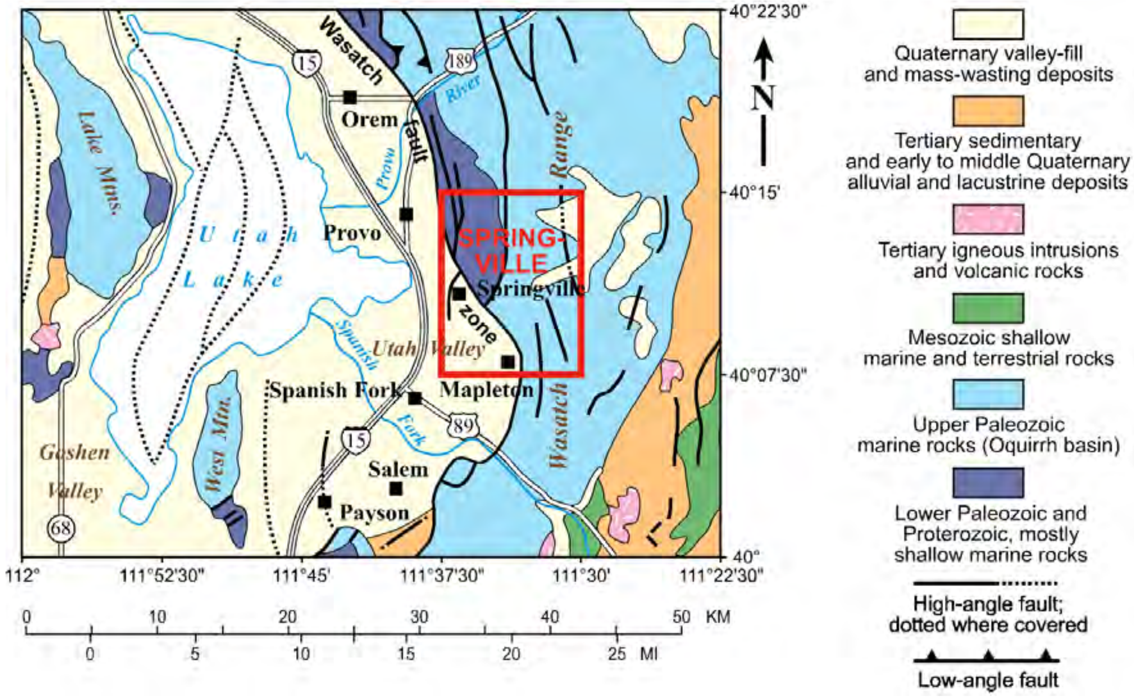


Figure 1. Index map showing the primary geographic features and generalized geology in the vicinity of the Springville quadrangle.

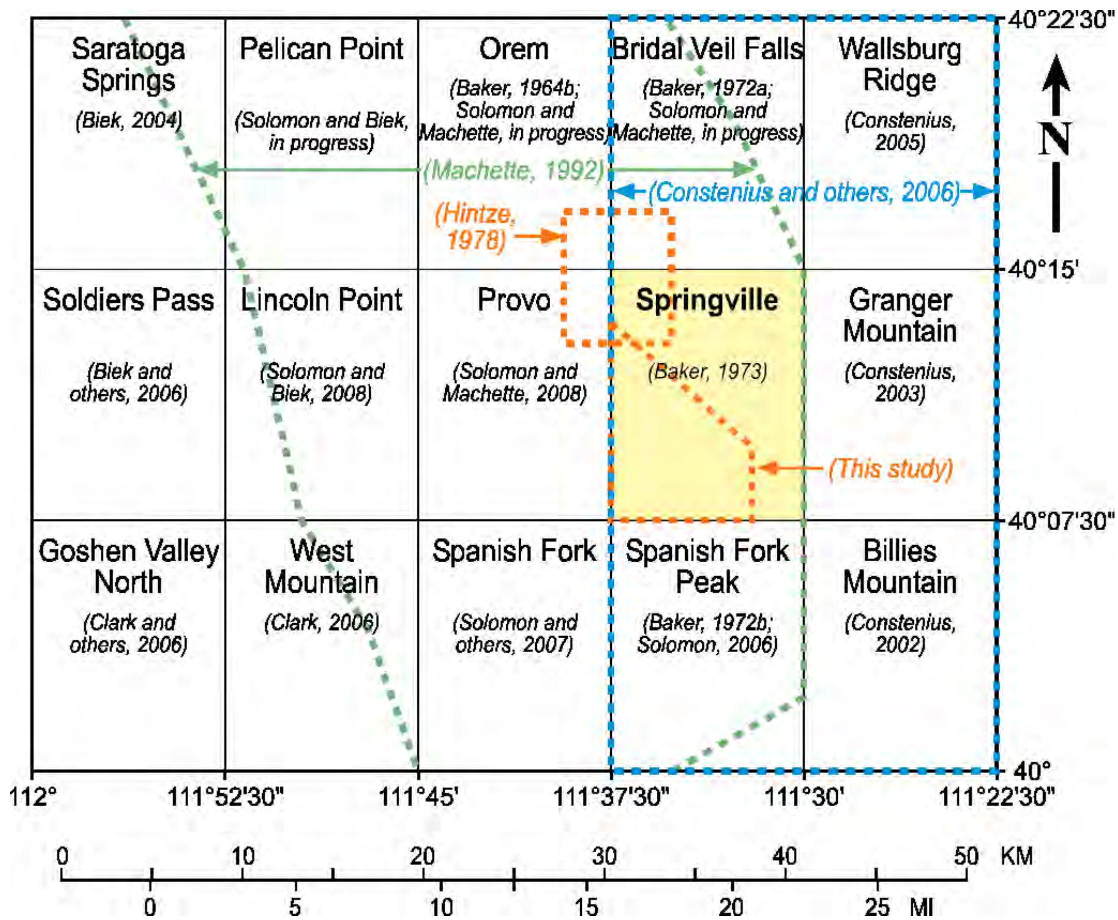


Figure 2. Index map showing selected geologic maps available for the Springville, and surrounding 7.5' quadrangles.

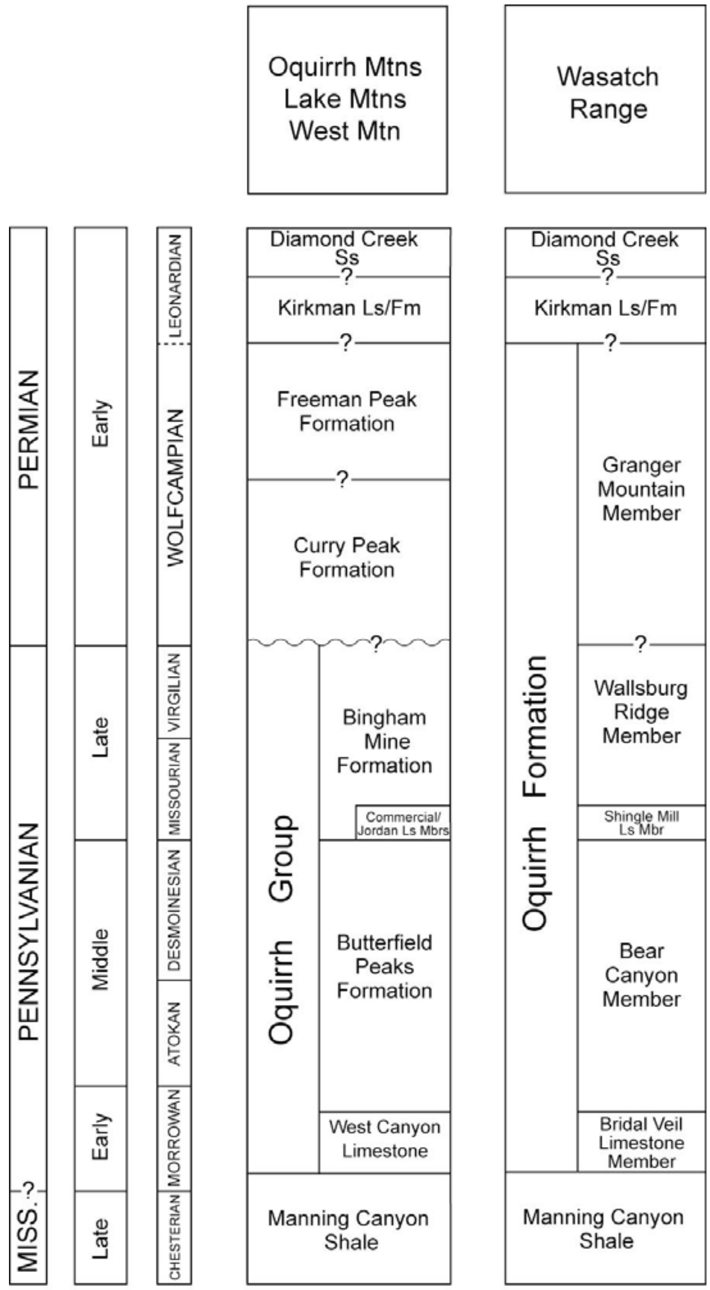
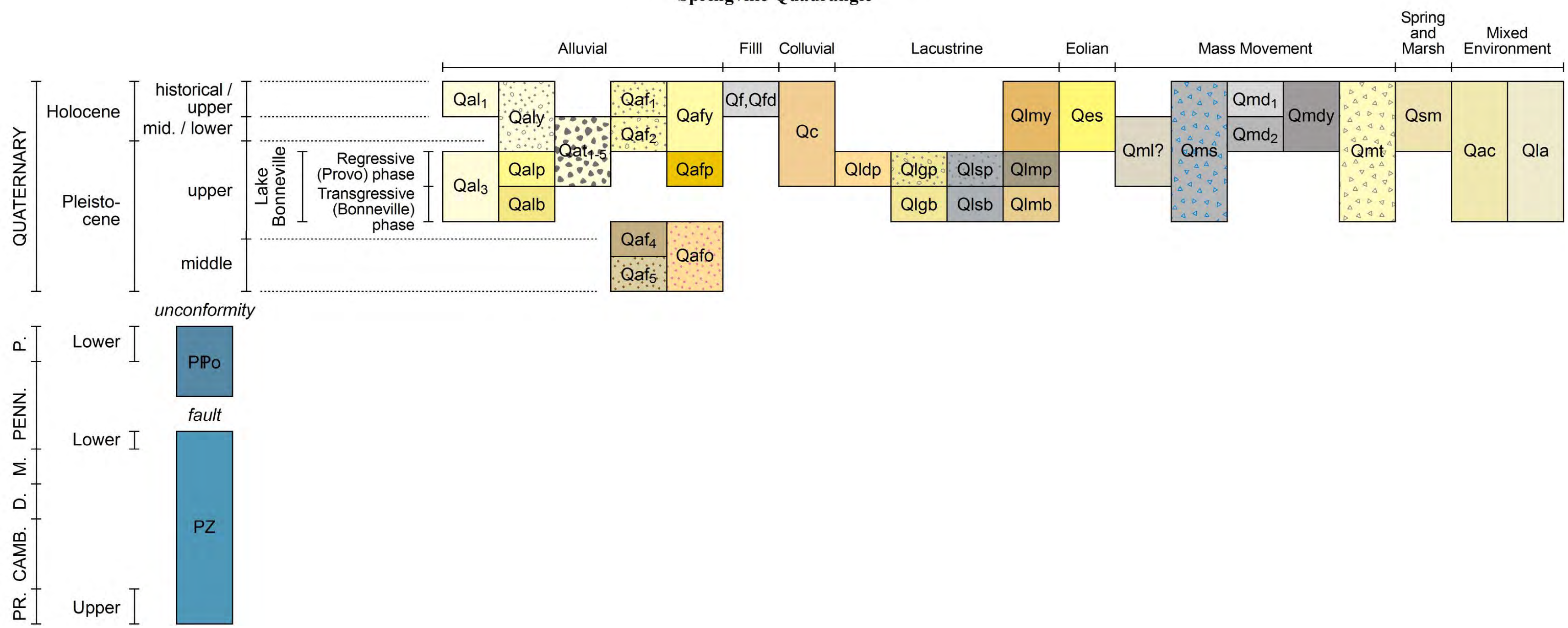


Figure 3. Comparison of stratigraphic nomenclature for the Oquirrh Formation/Group and associated strata near Salt Lake and Utah Valleys, north-central Utah.

CORRELATION OF MAP UNITS
Springville Quadrangle



GEOLOGIC SYMBOLS
Springville Quadrangle

Contact – Dashed where approximately located

Normal fault – Dashed where approximately located, dotted where concealed; bar and ball on down-dropped side

Thrust fault – Dotted where concealed and approximately located; teeth on upper plate

Lake Bonneville shorelines – Mapped at the wave-cut bench of erosional shorelines and the top of constructional bars and barrier beaches; may coincide with geologic contacts:

B Bonneville shoreline

Y Other transgressive shoreline

P Provo shoreline

X Other regressive shoreline

Crest of Lake Bonneville barrier beach or spit

Landslide scarp – Hachures on down-dropped side

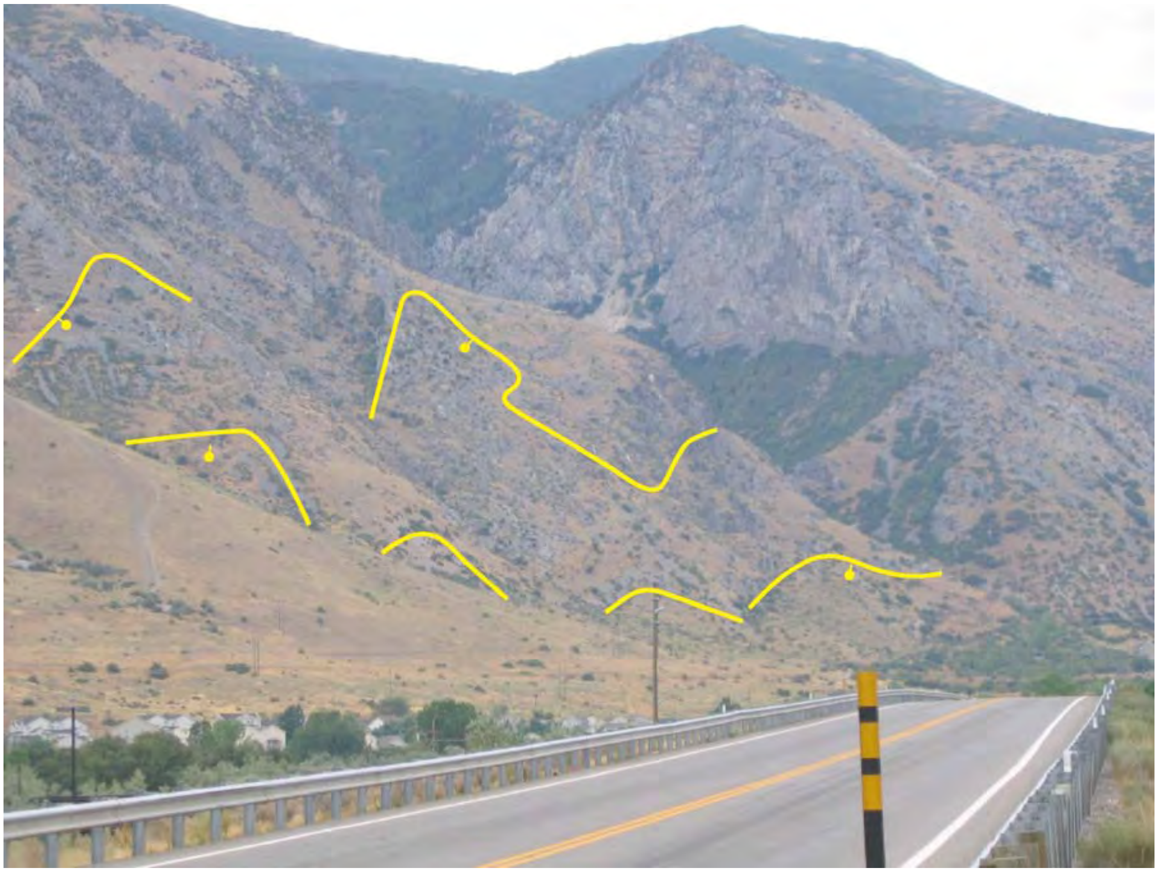
20 Strike and dip of inclined bedding (from Baker, 1973)

Sand and gravel pit

Spring

SP-1 Trench site for paleoseismic (Swan and others, 1980) and lateral-spread (Harty and Lowe, 2003) investigations

A large earthquake on the Springville fault, a splay of the Provo segment of the Wasatch fault zone, created a scarp that is visible as a change in the elevation of this street in a residential neighborhood of west Springville. The view is to the east, with the Wasatch Range in the background. The solid line indicates the location of the fault, with a bar and ball on the down-dropped side.



Range-front spurs northwest of Little Rock Canyon are crossed by two traces of the Wasatch fault zone. The upper fault lies within Paleozoic sedimentary rock (PZ) and the lower fault separates the bedrock from alluvial-fan deposit older than Lake Bonneville (Qafo). Solid lines indicate the location of the faults, with a bar and ball on down-dropped sides. Each fault is continuous, but the apparent discontinuities in the photograph result from the faults crossing gullies and passing behind slopes.

A landslide covers about 7 acres near the base of Twin Ridges on the east side of Springville. The landslide (Qms) exhibits hummocky terrain resulting from failure of transgressive Lake Bonneville sand and silt (Qlsb). The Bonneville shoreline (shown by the blue line and "B") lies above the landslide, and faults bound the landslide deposit both upslope and downslope. The yellow line indicates the location of the upslope fault, with a bar and ball on the down-dropped side, but the downslope fault is obscured by housing and vegetation near the landslide toe and is not visible in this photograph.